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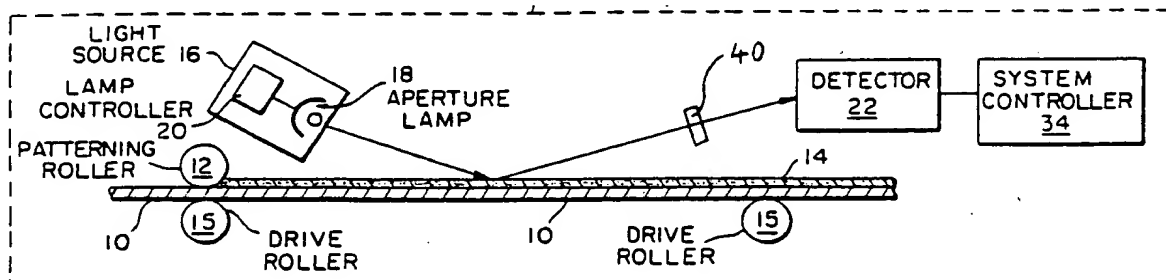
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(54) Method and apparatus for detecting the presence of a coating on a travelling web.

(57) A method and apparatus is disclosed that detects the specular reflections from the surface of a travelling web (10) to determine if a material (14) is coated on the web. The web is illuminated with diffuse light by a lamp (18) and the reflected light is received by a detector (22) which determines the presence and width of the coating material (14) based on the specular reflections from the coated surface of the travelling web.

FIG. 1

8 CIGARETTE MANUFACTURING MACHINE



# METHOD AND APPARATUS FOR DETECTING THE PRESENCE OF A COATING ON A TRAVELLING WEB

This invention relates to a method and apparatus for detecting the presence of a coating, for example an adhesive, on a travelling web. In particular, the invention relates to a method and apparatus that employs specular reflectance to determine the presence of a coating on cigarette tipping paper.

The improper application of adhesive to cigarette tipping paper has been shown to cause severe performance defects in a cigarette. In the least alarming aspects of its manifestations, the cigarette rod can come apart from the filter while the smoker is pulling the cigarette from the pack, the fold-over of the tipping paper can cause defects in the visual appearance of the product, and insufficient adhesive can impair the performance of the cigarette by changing the draft/dilution characteristics of the cigarette. In the extreme case, insufficient adhesive can cause a burning rod of tobacco to unexpectedly detach from the filter.

All of the aforementioned occurrences are a result of insufficient adhesive being applied to the edge of the tipping paper. For satisfactory adhesion, there must be at least 2 mm of adhesive on the outermost 5 mm of the tipping paper. It would be desirable, therefore, to have a method or device for detecting the presence of the adhesive as well as for quantitatively measuring the width of the adhesive applied to the tipping paper. Such a method or device would have to be capable of inspecting the tipping paper in the cigarette maker at speeds of up to 2.0 meters/second.

Systems have been developed for detecting the presence of the adhesive on a travelling web. U.S. Patent 2,141,052 discloses a system that measures the resistance of the paper as an adhesive is applied. The system disclosed, however, requires undesirable direct contact with the moving web. U.S. Patent 4,417,934 discloses a non-contact system that employs capacitive sensing to detect the presence of the adhesive. While this system avoids direct contact with the web, it is not suited to quantitatively measuring the width of the applied adhesive.

An object of the present invention is to provide a method and apparatus for detecting the presence of a coating, for example an adhesive, on a travelling web.

Viewed from a first aspect the invention provides an apparatus for detecting the presence of a coating material on a travelling web, said apparatus comprising:

a) illumination means for uniformly illuminating a surface of said travelling web with diffuse light at a first angle to produce first reflections from

a first portion of said surface coated with said coating material and second reflections from a second, non-coated portion of said surface:

b) detector means positioned at a second angle for receiving at least said second reflections from the surface of said travelling web; and

c) processing means for determining the presence of said coating material on said first portion of said surface of said travelling web based on differences in light intensity between said first and second reflections.

Viewed from another aspect the invention provides a method of detecting the presence of a coating material on a surface of a travelling web, said method comprising the steps of:

a) uniformly illuminating said surface of said travelling web with diffuse light at a first angle to produce first reflections from a first portion of said surface coated with said coating material and second reflections from a second, non-coated portion of said surface;

b) receiving at a second angle at least said second reflections from the surface of said travelling web; and

c) determining if said first portion of said travelling web has been coated with said coating material based on differences in light intensity between said first and second reflections.

Specular or mirror-like reflection occurs when the angle of incidence of the incoming light and the angle of observation of the reflected light are equal or at least approximately the same. With any system of reflected light, there will be a specular component and a diffuse component which together constitute 100% of the reflected light. For shiny or smooth surfaces, e.g., the adhesive area on a paper web, the majority of incident light, as measured at an angle from the normal to the surface of the web, is specularly reflected at an approximately equal angle from the normal. However, when the surface of the object is not smooth, as for example, the non-adhesive area of the paper web, light is scattered at different angles and, therefore, the majority of reflected light is diffuse and the specular component is minimal. This occurs since the microscope contours of the web surface which are responsible for reflectance of the light are not necessarily aligned parallel to the overall web surface.

For diffuse light sources, the incident light on any given point of the web emanates from a number of point sources, and thus the angle of incidence must be considered as a range of angles from the web reflectance point to the plural point sources. When a relatively rough surface such as the non-adhesive areas on the paper web are illu-

minated by a single point light source or by a light source having a relatively narrow range of angles of incident light, substantial amounts of reflected light can be observed at most angles of observation relative to the normal from the web surface, regardless of the angle or angles of incidence. On the other hand, with relatively smooth or substantially mirror-like surfaces and, when illuminated in the same manner, i.e., with a relatively narrow range of angles of incident light, the majority of light is specularly reflected at the same narrow range of angles measured with respect to the normal of the paper surface. Therefore, with this smooth surface, the amount of reflected light which can be observed will be small at most angles of observation (angles of observation which are different than the angles of illumination). Thus, when one observes incident light reflected from the surfaces of the smooth adhesive and the rough web, the optical gain, i.e., intensity of reflected light, of the adhesive is substantially different than the optical gain of the web or tipping paper. Specifically, when the source of illumination is a point source or a diffuse source providing a relatively narrow range of angles of incident light, if the reflected light is viewed at an angle of observation equal to, or within the range of, the angle of illumination, the optical gain from the smooth adhesive surface will be substantially higher than that of the rough web surface. On the other hand, with the same source of illumination, if the angle of observation is substantially different than the angle or angles of illumination, the optical gain of the smooth adhesive surface will be substantially lower than the optical gain of the rough web surface.

Because of these differences in intensity of reflected light from the rough (web) and smooth (adhesive) surfaces, the invention can be employed for the purposes of differentiating between adhesive and paper surfaces at substantially any combination of illumination and observation angles between 0 and the limit of 90°. Advantageously, the angle of incidence of the incoming light and the angle of observation of reflected light are selected to be equal and to be between approximately 45° and 90° from the axis normal to the tipping paper. In this instance, the light reflected from the adhesive will be of higher intensity than the light reflected from the rough web and thus, the adhesive will appear bright and the web dark (relative to the adhesive). In the preferred embodiment described herein, the differences between the adhesive and the paper are most readily apparent if the angle of incidence of the incoming light and the angle of observation of the reflected light are equal with respect to the surface normal and are limited to between about 70° and about 90°.

Alternatively, in another advantageous embodi-

ment, it is possible to take advantage of the relatively constant (over substantially any angle of observation between 0 and 90°) intensity of diffuse reflection of the paper surface and to employ the combination of angles of incident light and angles of observation which are outside the specular combinations for the adhesive surface: such as the combination of a small angle of incidence, e.g., between 0 and 20°, with a relatively large angle of observation, e.g., between 70° and 90°; or vice versa, i.e., large angles of incidence and small angles of observation. In this instance, the paper appears white or bright and the adhesive appears dark (relatively) since observation of light reflected from the adhesive surface is minimized.

Thus at least the preferred embodiments of the invention provide significant advantages over prior art devices in detecting both the presence and width of one or more lines of adhesive on tipping paper.

Some preferred embodiments of the invention will now be described by way of example and with reference to the accompanying drawings, in which:-

Fig. 1 is a block diagram of a cigarette manufacturing machine incorporating the present invention;

Fig. 2 is a schematic block diagram of a detector employed in the present invention;

Fig. 3 is a diagram illustrating the angle of incidence of illuminated light and the angle of observation of specular reflections employed in the present invention;

Figs. 4a-6a represent typical adhesive patterns detected by the present invention;

Figs. 4b-6b represent the output signal from a CCD line scanner for the detector shown in Fig. 2 when viewing the adhesive patterns shown in Figs. 4a-6a respectively; and

Fig. 7 illustrates a second embodiment of the present invention.

A cigarette manufacturing machine 8 is shown in Fig. 1, wherein a web of tipping paper 10 for use in cigarettes is drawn past a patterning roller 12 that applies an adhesive layer 14 to the surface of the tipping paper 10. As the tipping paper 10 is drawn along the transport path by drive rollers 15, the surface of the paper 10 is illuminated by a light source 16. The light source 16 is comprised of a fluorescent aperture lamp 18 that provides diffused and spectrally stable light. A lamp controller 20 is provided to regulate the output of the lamp 18 and prevent ripple. The lamp controller 20 also overdrives the fluorescent aperture lamp 18 in order to obtain sufficient illumination for the detector 22. The lamp controller 20 and fluorescent aperture lamp are readily available components. (For example, MERCRON of Richardson, Texas is one company that produces lamp controllers for fluorescent

tipping paper 10 to the detector 22.

The detection of the specular reflections from the adhesive layer 14 and the tipping paper 10 permits accurate determination of the presence and width of the adhesive layer 14 not previously achieved in prior art devices. The diffuse light source employed in the present invention enhances the uniformity of specular reflections from the adhesive layer 14 and the tipping paper 10, allowing for easy detection of the edge transitions between the adhesive layer 14 and the surface of the tipping paper 10 by the detector 22.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the scope of the invention. For example, a 256 x 256 array scanner may be employed with a separate micro-processor performing the edge detection algorithms. In this case a single line of the array is utilized for data analysis.

It will thus be seen that at least in its preferred forms, the invention provides a method and apparatus for detecting the boundary between two surfaces of a web, one surface being substantially smooth and the other being relatively rough; a method and apparatus that can detect the width of the adhesive applied to the travelling web; apparatus for detecting the presence of an adhesive on a travelling web having a structure that can easily be employed in a cigarette making machine; and a method and apparatus that optically enhances the differentiation of the adhesive from the tipping paper by detecting the differences in the specular reflectance of the adhesive and the paper.

It is to be clearly understood that there are no particular features of the foregoing specification, or of any claims appended hereto, which are at present regarded as being essential to the performance of the present invention, and that any one of more of such features or combinations thereof may therefore be included in, added to, omitted from or deleted from any of such claims if and when amended during the prosecution of this application or in the filing or prosecution of any divisional application based thereon. Furthermore the manner in which any of such features of the specification or claims are described or defined may be amended, broadened or otherwise modified in any manner which falls within the knowledge of a person skilled in the relevant art, for example so as to encompass, either implicitly or explicitly, equivalents or generalisations thereof.

## Claims

1. Apparatus for detecting the presence of a coating material on a travelling web, said apparatus comprising:

a) illumination means for uniformly illuminating a surface of said travelling web with diffuse light at a first angle to produce first reflections from a first portion of said surface coated with said coating material and second reflections from a second, non-coated portion of said surface;

b) detector means positioned at a second angle for receiving at least said second reflections from the surface of said travelling web; and

c) processing means for determining the presence of said coating material on said first portion of said surface of said travelling web based on differences in light intensity between said first and second reflections.

2. Apparatus as claimed in claim 1, wherein said processing means determines the width of said coating material based on the first reflections received by said detector means.

3. Apparatus as claimed in claim 1 or 2, further comprising means for directing said first reflections to said detector means.

4. A method of detecting the presence of a coating material on a surface of a travelling web, said method comprising the steps of:

a) uniformly illuminating said surface of said travelling web with diffuse light at a first angle to produce first reflections from a first portion of said surface coated with said coating material and second reflections from a second, non-coated portion of said surface;

b) receiving at a second angle at least said second reflections from the surface of said travelling web; and

c) determining if said first portion of said travelling web has been coated with said coating material based on differences in light intensity between said first and second reflections.

5. A method of detecting the presence of a coating material on a surface of a travelling web as claimed in claim 4, further comprising the step of determining the width of said coating material based on the first reflections.

6. Apparatus or a method as claimed in any preceding claim, wherein said first and second angles are approximately equal such that said first reflections include a predominantly specular component and said first and second angles are each about 45° to 90° from an axis normal to said travelling web.

7. Apparatus or a method as claimed in claim 6, wherein said first and second angles are at least approximately equal and about 70° to 90° from said axis normal to said travelling web.

8. Apparatus or a method as claimed in any of claims 1 to 5, wherein said first angle is less than 45° from an axis normal to the travelling web, and said angle is between 70°-90° from said axis.

9. Apparatus or a method as claimed in any of claims 1 to 5, wherein said first angle is between 0°-20° from an axis normal to the travelling web, and said second angle is between 70°-90° from said axis.

10. Apparatus or a method as claimed in any of claims 1 to 5, wherein said first angle is between 0°-40° from an axis normal to the travelling web, and said second angle is between 50°-90° from said axis.

11. Apparatus or a method as claimed in any of claims 1 to 5, wherein said first angle is between 50°-90° from an axis normal to the travelling web, and said second angle is between 0°-40° from said axis.

12. Apparatus or a method as claimed in any of claims 1 to 5, wherein said first angle is between 70°-90° from an axis normal to the travelling web, and said second angle is between 0°-20° from said axis.

13. Apparatus as claimed in any of claims 1 to 3, further including a polarizing filter disposed between said web and said detector.

14. Apparatus as claimed in claim 13, wherein said first and second angles are each approximately equal to Brewster's angle.

15. Apparatus for detecting the presence of a relatively smooth material on a relatively rough web, said apparatus comprising:

a) illumination means for uniformly illuminating a surface of said web with diffuse light at a first angle to produce first reflections from a first portion of said surface having said relatively smooth material thereon and second reflections from a second portion of said surface not having said relatively smooth material thereon;

b) detector means positioned at a second angle for receiving at least said second reflections from the surface of said web; and

c) processing means for determining the presence of said relatively smooth material on said first portion of said surface of said web based on differences in light intensity between said first and second reflections.

16. A method of detecting the presence of a relatively smooth material on a surface of a relatively rough web, said method comprising the steps of:

a) uniformly illuminating said surface of said web with diffuse light at a first angle to produce first reflections from a first portion of said surface having said relatively smooth material thereon and

second reflections from a second portion of said surface not having said relatively smooth material thereon;

b) receiving said second reflections from the surface of said web at a second angle; and

c) determining if said first portion of said web has said relatively smooth material thereon based on the differences in light intensity between said first and second reflections.

17. A method of detecting the presence of a coating material on a surface of a travelling web comprising the steps of:

a) illuminating, at an angle of incidence, said surface of said travelling web with a diffuse light source to produce first reflections from a first portion of said surface coated with said coating material and second reflections from a second portion of said surface not coated with said coating material, said first reflections having a first light intensity when observed at an angle of observation substantially equal to said angle of incidence, and a second intensity when observed at an angle of observation not substantially equal to said angle of incidence, said second reflections having a range of third light intensities intermediate said first and second light intensities,

b) positioning a light detector at an angle of observation for receiving at least said second reflections, and

c) automatically determining whether said web contains said first portion based on the difference in light intensities between said first, second and third intensities.

18. A method as claimed in claim 17, wherein said step of positioning said light detector includes positioning said light detector at an angle of observation substantially equal to said angle of incidence so as to receive, in addition to said second reflections, said first reflections having said first light intensity.

19. A method as claimed in claim 18, further comprising the step of determining the width of said first portion.

20. A method as claimed in any of claims 17 to 19, wherein said angle of incidence is between about 70 to 90° as measured from an axis normal to said travelling web.

21. A method as claimed in any of claims 17 to 19, wherein said angle of incidence is between about 45 to 90° as measured from an axis normal to said travelling web.

22. A method as claimed in claim 17, wherein said step of positioning said light detector includes positioning said light detector at an angle of observation not substantially equal to said angle of incidence so as to receive, in addition to said second reflections, said first reflections having said second light intensities.

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FIG. 4a

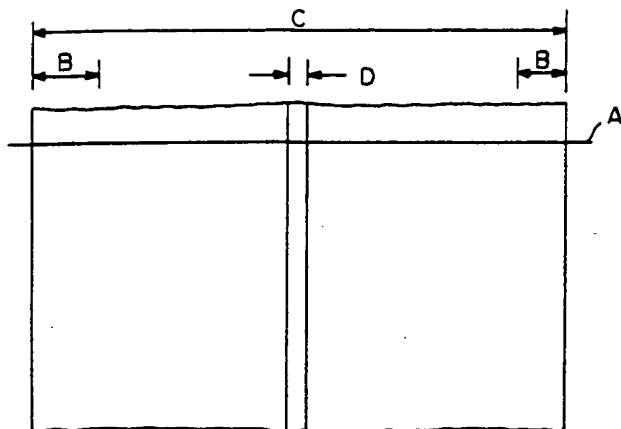


FIG. 4b

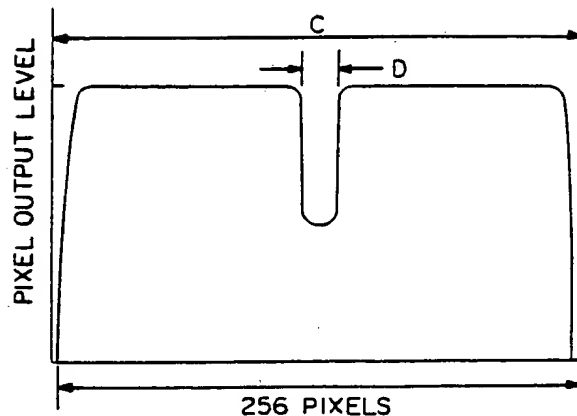


FIG. 5a

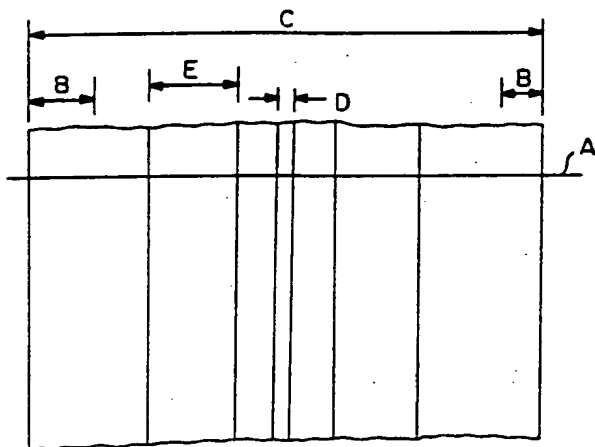


FIG. 5b

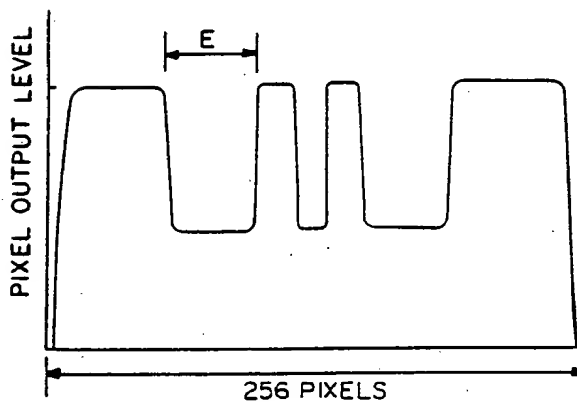


FIG. 6a

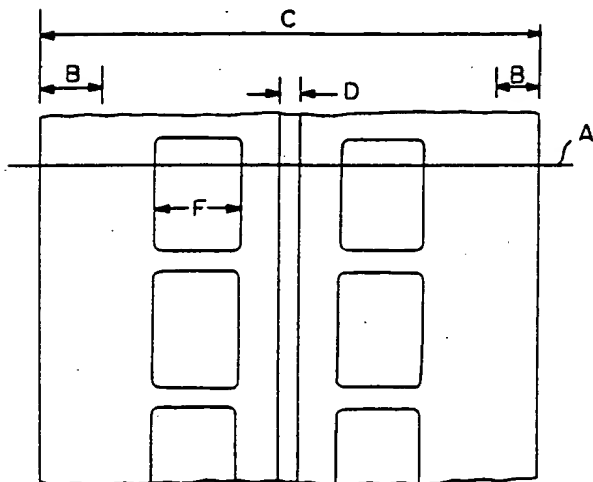
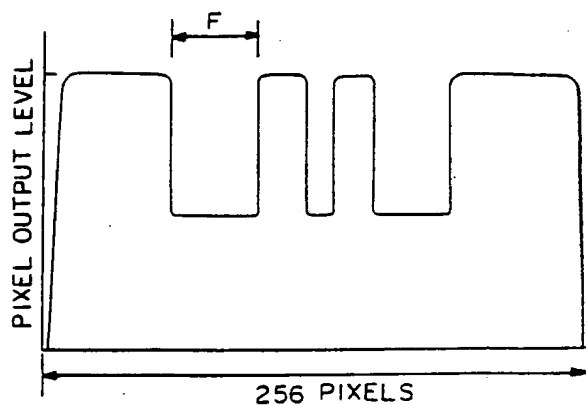


FIG. 6b



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